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CLIMATE AND WEATHER AT KERGUELEN ISLAND

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Volume III, Part 3, of the results of the German South Polar Expedition of 1901-1903, is the subject of a review by Dr. Ludwig Meckling in Petermann's Mitteilungen, 1926, Heft 9/10. The meteorological results obtained at "Gauss Station" in the Antarctic have been presented and exhaustively discussed by Meinardus in preceding volumes. The *Gauss* on her way south left an observing party on Kerguelen, who, during a full year thereafter, obtained the observations now similarly treated by Meinardus. That many problems remain unsolvable because of shortness of the record, he clearly indicates; nevertheless, the *Gauss* observations make available for the first time a means for outlining the general characteristics of the year-round climate in this desperately storm-ridden part of the South Indian Ocean. The fact that such can be done with reasonable completeness on the basis of one year's data, supplemented by collateral evidence from the scattered records made by various agencies since Sir James Ross's pioneer observations in the winter of 1840, is, of course, because Kerguelen shares with oceanic islands in pleasanter latitudes the monotony of weather and climate induced by pure marine control.

But in Kerguelen's case, what a monotony! It is that of a climate so cold that snow may fall on any day in the year, though warm enough for the mean temperature of no month to be below freezing; so cold that frosts occur on 140 days annually, but so warm that the ground never freezes deeper than 5 cm.; cold enough to have the lowest temperature below freezing on 248 days annually, yet warm enough to have more rainy days than snowy. The seeming anomaly of frost occurrence only about six-tenths as often as the occurrence of a minimum air temperature below freezing, is ascribed by Meinardus to the fact that the permanently water-logged condition of the boggy ground which predominates throughout the island so reduces the diurnal oscillation of ground temperature as to prevent the formation of a large proportion of the frosts that would otherwise occur. The ground temperature is below the air temperature but a short time in midwinter.

The very slight daily and annual ranges of air temperature reflect the completeness of the marine control over Kerguelen's climate. With an annual mean temperature of 37.8 degrees F., the annual mean range is but 11.9 degrees and the daily periodic range only 3.8 degrees.

Observatory Bay, Kerguelen Island, where the Gauss observations were taken, is in latitude 49° 23' S. and longitude 69° 54' E., in the heart of the stormy westerlies on the steep pressure gradient leading to the bottom of the barometric trough that girdles Antarctica. The mean pressure at Kerguelen is 752 mm. During the year at Observatory Bay the cycle of pressure changes from the minimum of one depression in the barogram to the minimum of the next (counting changes of 5 mm. or more) was run through on the average in 2 days, 21 hours. Meinardus holds that such rapidity of change may be due, in part, to the fact that the discontinuity between polar waters and those under the westerlies, for this part of the world, lies near Kerguelen. At any rate the record at the island shows the greatest persistence of heavy winds of which we have any knowledge. One is not surprised that under such conditions the average wind velocity is 19.2 m. p. h., or that winds of gale force are recorded on one day out of four. This constancy of high winds stands

in contrast to the alternation of gales and calms which is characteristic of points along the coast of Antarctica. But the storms of Kerguelen are less severe and last not so long as the Antarctic storms. The contrast in wind conditions is still further emphasized by the percentage frequencies of winds from different quadrants at Kerguelen and at "Gauss Station" in the Antarctic:

Quadrant	N.	E.	S.	W.	Calm.
Kerguelen	11	4	6	75	4
"Gauss Station"	1	65	11	12	11

Wind frequencies and velocities run parallel at Kerguelen, so that the westerlies are the heaviest winds. The approach of depressions from the west is heralded typically by violent NNW. squalls.

Of the prevailing northwesterlies and of the respites from them enjoyed by the inhabitants at the whaling station on this dreary outpost, the following extracts from the South Indian Ocean Pilot of the British Admiralty give a vivid impression:

This wind is often deflected on the lee side by the steep valleys and fiords which intersect the island, usually taking the direction of a valley, which acts as a funnel, and descending in heavy gusts or whirlwinds, raises large sheets of foam. So violent are these gusts in Christmas Harbor that Sir James Ross was frequently obliged to throw himself on the ground to prevent being blown into the water; and vessels moored at the head of the harbor were sometimes laid over on their beam ends.

M. Bossière says: "The wind at frequent intervals blows with great violence, but it is more terrifying than dangerous. It is an error to seek shelter at the foot of the mountains. The wind falls there like a veritable cascade and the sea is ground into powder."

On the western or weather side of the island the air, saturated with moisture, impinging on the steep mountain ranges, causes frequent showers of snow, hail, or rain, and the clouds arrested by the hills accumulate and descend, causing mists and fogs; whilst, as is usually the case, on the leeward side the air is generally dry and there is but little fog.

The prevailing westerly wind is sometimes interrupted by northeasterly and northerly winds, which blow with considerable force, and during their continuance the sky is overcast and the weather thick and rainy; they usually follow a high barometer and fine weather. Just before they commence the barometer falls rapidly and the thermometer rises, and their duration is inversely as the rate of descent of the barometer.

Occasionally, but very rarely, the usually boisterous weather is interrupted by a calm or a light easterly wind, when the sky is perfectly free from cloud and the atmosphere is remarkably clear, every hill-top being distinctly visible; this seldom lasts 24 hours and is generally succeeded by a gale.

It will be inferred from the table of wind-direction frequencies given above and from the description following it, that Kerguelen lies not far from and north of a well-frequented track of depressions in that part of the world.

The rapidity with which cloudiness changes is in harmony with the rapid passage of pressure waves. To state that mean cloudiness at Kerguelen is 0.7 signifies little, for in this bleak land where not a single day in the year of the *Gauss* observations had cloudless skies at all three observation hours, nevertheless on only 106 days was a completely overcast sky observed and but 35 days had no sunshine whatever.

This means, literally, that the sun shone for at least a brief period on 330 days in the year; but how slight the cheer in a figure like that when, in addition to the wind and low temperature and high relative humidity, the

chance of precipitation is 80 per cent, the rainy spells average 8.3 days in length and the "dry" spells 1.9 days. It rarely rains hard, however. In giving the annual total of approximately 850 mm. (34 inches), about half the days had less than 1 mm., while the maximum 24-hour rainfall was but 42.6 mm. (1.70 inches). Precipitation, except for the very rare local showers, comes as a driving, chilling drizzle or as a gale-borne sleet and snow. The winter is characterized by frequent brief snowfalls, most of its precipitation being in this form. Spring is the snowiest season and October the snowiest month. More than half the days of the year have snow, but the land-

scape is snow covered on only a third of the days. In the words of Meinardus:

The winter brings the greater total of precipitation, greater violence and frequency, but shorter duration; the summer brings less, more gentle, and rarer but more lasting precipitation. * * * The observer on Kerguelen will, even in midsummer, when the sun stands 60 degrees above the horizon, be reminded of winter by snow flurries, and he can never be sure whether the snowfalls which he then records should be regarded as a remnant of the bygone winter or as a forerunner of the coming one. In this disagreeable condition he may recognize a far-reaching effect of the Antarctic, extending its merciless influence through the chilly oceanic spaces into Kerguelen's latitude and beyond.

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NOTES, ABSTRACTS, AND REVIEWS

AEROLOGICAL WORK OF THE GERMAN SOUTH ATLANTIC EXPEDITION ENDING APRIL, 1926¹

The *Meteor*, on which the scientific work of the expedition was carried out, ended her fifth "profile" cruise at Cape Town early in April, 1926. Her first five cross-Atlantic voyages took place between latitudes 28° and 64° S. Each was run for as great a distance as practicable nearly along a parallel of latitude, largely between Buenos Aires and Cape Town as bases. A comprehensive aerological program formed part of the scientific objectives of the expedition.

A total of 354 pilot balloon ascents were made. Of these, 292 averaged 3,560 m. in height. Of these again, 25 per cent passed 5,000 m., and about 10 per cent 10,000 m., surely an excellent achievement in view of unsettled weather and relatively high winds experienced during much of the time. The intention to carry out two ascents daily was adhered to except when the weather made them impossible. This meant that many observations were made when clouds soon obscured the balloon; but the total of such cases, plus those in which kites also disappeared in the clouds, made possible a very accurate fixing of the altitudes of cloud bases on 185 occasions and for several different cloud types.

Kite flights totaled 67 for the 5 voyages, and there were determinations of cirrus direction and velocity on 46 days, many of the latter in double series.

Difficulties with the kites were numerous and persistent, especially during the earlier voyages of the series. On profile IV, the first part of the voyage was so boisterous as to call for the use of small "storm kites" and heavy wire, thus restricting the heights attained. Special trouble was encountered in the landings. The ship being often under sail to save coal, or hove to with engines going for making deep-sea soundings, the kites frequently plunged wildly in the atmospheric eddies caused by the sails or were smashed by the propellers when pressed down to the surface of the sea by gusts. Headlong dives, and sometimes the loss of the kites and instruments, fol-

lowed the catching of the kite wire in the rigging. The assistant personnel frequently found itself being pulled along the slippery, heaving deck by the tugging kites. The net result of these exciting experiences was a total of 10 successful kite flights for the whole voyage on profile IV.

The last voyage was the most varied of all as regards conditions for aerological work, but nevertheless probably the most successful. Between its beginning at Buenos Aires and the first stop, Punta Arenas, the total of 20 pilot balloon ascents reached an average altitude of 8,860 m., 14 exceeded 5,000 m., 7 went beyond 10,000 m., and 1 balloon reached 20,250 m. The *Meteor* steamed thence southward via inside channels, passed out into the Southern Ocean within sight of Cape Horn, and in extraordinarily fine weather for the latitude crossed to the South Shetland Islands. She went thence to South Georgia and Bouvet Island and thence as far south as ice conditions permitted, accomplishing altogether 25 kite flights to an average height of 1,900 m. and a maximum of 3,510 m. Four flights were carried out south of latitude 64°. One flight, between South Georgia and Bouvet Island, took place close to the center of a cyclone, in thick cloud and snow squalls. It will be of interest here to quote from the report a section showing how the aerologists of the expedition met the difficulties encountered on this far southern voyage:

The weather was generally better west of longitude 18° W., and many successful flights were there made. Nevertheless, on account of short coal supply the ship was in a number of cases not able to maneuver for the benefit of the kite work; the flights always involved a loss of time and distance. * * * The great number of flights was made possible by a change in technique. Our earlier experience had been that it was impracticable to carry out kite flights while the ship was making a sounding, because whatever might be happening to the kites the ship was not free to maneuver on account of the lead line. In many cases we lost kites on this account. Of the 25 ascents on profile V, 15 were accomplished during deep-sea soundings, the lack of safety being compensated for by using a thicker wire, the reel drum being wound with 0.8 and 0.9 mm. wire. As a result, in spite of much heavier winds, we had no breakaways.

For the whole of this last voyage, pilot balloon flights totaled 57 and the altitudes averaged 3,130 m. Of these, 11 ascents exceeded 5,000 m., 4 exceeded 10,000 m., and 1 reached 14,800 m.

The importance of the aerological work carried out by the *Meteor* in these remote latitudes can scarcely be overestimated. Interpretation of the results will be awaited with the greatest interest.—B. M. V.

¹ Die Deutsche Atlantische Expedition auf dem Vermessungs- und Forschungsschiff "Meteor." Part 2. See *Zeitschr. der Gesell. für Erdkunde*, Berlin, Jahrgang 1926, Nr. 5/6. Part 1 of this report appeared in the same journal, 1926, no. 1. The section on meteorology of Part 2 is by J. Reger and E. Kuhlbrodt. Another report on the expedition, by the scientific director, Dr. A. Merz, is contained in *Vorträge der Preussischen Akademie der Wissenschaften*, 1925, XXXI, and constitutes a preliminary report on some of the scientific results. It includes a chart of the 14 profiles run by the *Meteor*. Chief among the charts showing scientific results of the expedition are: A temperature cross section for the upper 1,000 m. of depth in the South Atlantic along latitude 35° S.; a temperature cross section from latitude 70° N. to 30° S. along the meridian of 30° W. in the Atlantic; the temperature distribution at 400 m. depth in the North Atlantic; a salinity cross section from latitude 70° N. to 80° S. along 30° W. longitude.